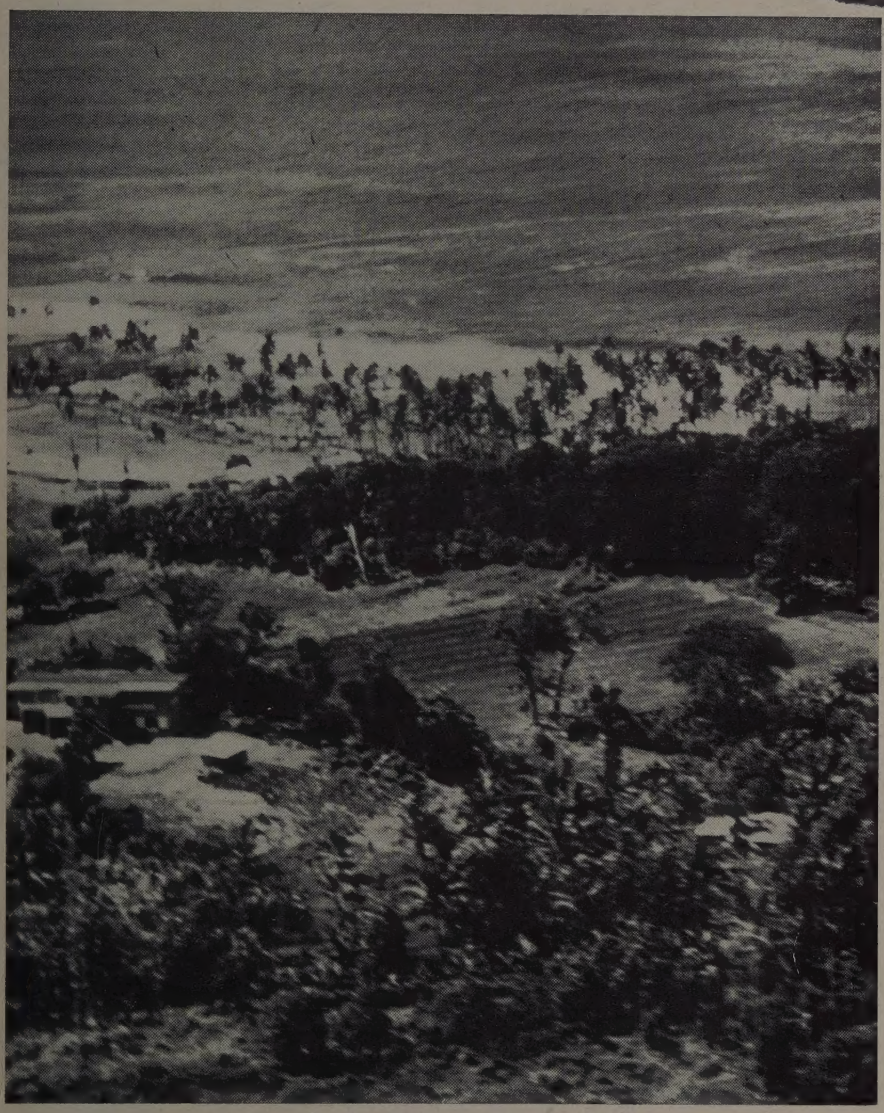
VOLUME LI NUMBER 2

THE HAWAIIAN PLANTERS' RECORD



Aerial view of the Experiment Station, H.S.P.A.
Substation on American Samoa

SECOND QUARTER 1947

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ADVERTISER PUBLISHING CO., LTD.
HONOLULU, HAWAII, U. S. A.

THE HAWAIIAN PLANTERS' RECORD

Vol. LI SECOND QUARTER 1947 No. 2

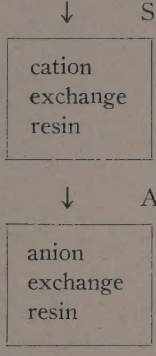
A quarterly paper devoted to the sugar interests of Hawaii and issued by the Experiment Station for circulation among the plantations of the Hawaiian Sugar Planters' Association.

Ion Exchange

By Hugo P. Kortschak

In view of the increasing use of ion exchange in Hawaii, it seems appropriate to present a brief description of the process here.

Ion Exchange is a method for removing salts from water. Two kinds of ion exchange resins, coarsely ground, are needed. When salt water is run through the first (cation exchange) resin, the water coming out contains not salt, but acid. This is removed by the second (anion exchange) resin, giving pure water.



Chemically, the cation exchange resin is an insoluble, solid acid. Like other acids it can give off hydrogen ions. When the resin is placed in pure water, the hydrogen ions cannot be removed from the resin, as they are positively electrically charged, and attracted by the negative electric charge on the remainder of the resin. If, however, the water contains the positive sodium and negative chloride ions of common salt, the sodium ions are also attracted by the resin. Then, when a hydrogen ion moves slightly away from the resin, its place may be occupied by a sodium ion. As a net result, the water contains fewer sodium, and more hydrogen ions; in other words, less salt and more acid.

If the water is poured off the first piece of resin, and onto another, the same process occurs again, and this may be repeated until no salt, but only acid, remains in the water. Practically, this same result is reached by allowing the solution to flow through a column of the ground resin. Any positive ion (cation), such as calcium, potassium, ammonium, etc., will be exchanged for hydrogen ions in the same way.

To make the cation exchange resin usable again, an acid, usually sulfuric, is flowed over it. Now the reverse process takes place; hydrogen ions displace the other positive ions which the resin took up, and it is again ready for use. This is called regeneration.

Similarly, the anion exchange resin is a solid, insoluble base. However, we are not as certain of the method by which these resins remove acids from water. One theory is that the resin combines with the whole molecules of the acid, without releasing any ions into the solution. This really should not be called ion exchange at all. The other possibility is that the resin can give off hydroxyl ions. These may be replaced by the negative ions (anions) of an acid, such as chloride, sulfate, citrate, etc. The hydroxyl ions would then simply combine with the hydrogen ions of the acid to form more water.

The anion exchange resin is regenerated with an alkali such as caustic soda or ammonia, which either neutralizes the combined acid on the resin, or furnishes hydroxyl ions to replace the other anions.

Ion Exchange and Sugar

The use of ion exchange in purifying sugar solutions is based on the fact that sugars do not break up into ions when dissolved in water. Therefore they are not electrically charged, and not attracted by the resins. Thus we can remove the salts from sugar solutions without loss of sugar.

When treating cane juice, ion exchange can give a purity increase of five to ten points, with a consequent increase in the amount of sugar which can be crystallized. In addition, the resins remove most of the color from the juice, so that a light-colored, or even a white sugar is obtained.

Throughout the sugar industry investigations of the application of ion exchange are under way. So far, the results have not led to successful operations on a factory scale. In Hawaii, Dr. J. H. Payne, Research Director of the Pacific Chemical and Fertilizer Company, has directed research in this field for the H.S.P.A. since 1943. Laboratory results have been sufficiently promising so that a pilot plant has recently been set up at Oahu Sugar Company to test the methods developed on a larger scale.

Some Insect Pests of the Mainland of the United States Occurring Also in Hawaii

By C. E. Pemberton

The following list includes common insect pests established in Hawaii which also occur on the mainland of the United States. Beneficial insects in the same category, of which there are many, and a number of other insects of no economic importance, which also occur in both regions are not listed. The information is assembled primarily to indicate the importance and need for the enactment and enforcement of quarantine regulations against mainland insects coming into Hawaii on aircraft and surface ships.

1. *Agromyza simplex* Loew.....Asparagus miner
2. *Agromyza virens* Loew.....Stem miner in zinnia, sunflower, etc.
3. *Agrotis ypsilon* Rott.....Garden cutworm
4. *Amphoraphora sonchi* (Oestlund).....The sonchus aphid
5. *Anthonomus eugenii* Cano.....Pepper weevil
6. *Anthrenus scrophulariae* (Linn.).....Carpet beetle
7. *Antonina graminis* (Mask.).....Rhodes-grass scale
8. *Aphis ferruginea-striata* Essig.....Rusty-banded aphid. Celery aphid
9. *Aphis gossypii* Glover.....Melon aphid
10. *Aphis helichrysi* Kalt.....Plum aphid
11. *Aphis maidis* Fitch.....Corn aphid
12. *Aphis medicaginis* Koch.....Cowpea or bean aphid
13. *Aphis middletoni* Thomas.....Aster root aphid
14. *Aphis rumicis* Linn.....Dock or lima bean aphid
15. *Aspidiotus camelliae* Sign.....Greedy scale
16. *Anacamptodes fragilaria* (Grossbeck).....Algarcba moth
17. *Autographa brassicae* Riley.....Cabbage looper
18. *Bedellia somnulentella* Zeller.....Morning-glory leaf miner
19. *Blattella germanica* (Linn.).....German cockroach
20. *Brevicoryne brassicae* (Linn.).....Cabbage aphid
21. *Bruchus amicus* (Horn).....Amicable bean weevil
22. *Bruchus obtectus* (Say).....Bean weevil
23. *Bruchus prosopis* (Lec.).....Desert or algaroba weevil
24. *Bruchus pruininus* Horn.....Pruinose bean weevil
25. *Bruchus quadrimaculatus* (Fabr.).....Four-spotted bean weevil
26. *Calandra granaria* (Linn.).....Granary weevil
27. *Calandra oryzae* (Linn.).....Rice weevil
28. *Calliphora vomitoria* (Linn.).....Bluebottle fly
29. *Capitophorus braggii* (Gillette).....Artichoke aphid
30. *Cerataphis lataniae* (Boisduval).....Palm aphid
31. *Cerosipha subterranea* (Mason).....Guayule aphid
32. *Chrysomphalus aonidum* (Linn.).....Florida red scale
33. *Cimex lectularius* Linn.....Bed bug
34. *Cirphis unipuncta* (Haw.).....Armyworm
35. *Contarinia sorghicola* (Coq.).....Sorghum midge
36. *Coccus hesperidum* Linn.....Soft brown scale
37. *Corizus hyalinus* (Fabr.).....Hyaline grass bug
38. *Ctenocephalides felis* (Bouche).....Cat flea
39. *Cylas formicarius elegantulus* (Summers).....Sweet potato weevil
40. *Cyrtopeltis varians* Dist.....Tomato bug

41. *Danaus plexippus* (Linn.) ..... Monarch butterfly
42. *Deilephila lineata* (Fabr.) ..... White-lined sphinx moth
43. *Dermestes vulpinus* (Fabr.) ..... Hide beetle
44. *Diachus auratus* (Fab.) ..... Bronze willow flea beetle
45. *Diaspis echinocacti* (Bouche) ..... Cactus scale
46. *Dinocampus terminatus* (Nees) ..... Ladybeetle parasite
47. *Diplazon laetatorius* (Fabr.) ..... Parasite of beneficial syrphid flies
48. *Draeculacephala mollipes* (Say) ..... Sharpshooter
49. *Echidnophaga gallinacea* (Westwood) ..... Sticktight flea
50. *Empoasca solana* DeLong ..... Bean leafhopper
51. *Eomenacanthus stramineus* (Nitzsch) ..... Chicken body louse
52. *Epitrix parvu'a* (Fabr.) ..... Tobacco flea beetle
53. *Eriosoma lanigera* (Hausmann) ..... Woolly aphis of apple trees
54. *Gasterophilus intestinalis* (De Geer) ..... Horse botfly
55. *Gnorimoschema operculella* (Zeller) ..... Potato tuber moth
56. *Goniocotes gigas* Taschenberg ..... Large chicken louse
57. *Heliothis armigera* (Hub.) ..... Corn earworm
58. *Hellula undalis* (Fabr.) ..... Cabbage webworm
59. *Hermetia illuscens* (Linn.) ..... Soldier fly
60. *Hymenia recurvalis* (Fabr.) ..... Hawaiian beet webworm
61. *Hylemyia cilicrura* (Rondani) ..... Seed-corn maggot
62. *Hypoderma lineatum* (De Villers) ..... Common cattle grub
63. *Icerya purchasi* Mask. ..... Cottony cushion scale
64. *Idiopterus nephrelepidis* Davis ..... Fern aphid
65. *Iridomyrmex humilis* Mayr ..... Argentine ant
66. *Keiferia lycopersicella* (Busck) ..... Tomato pinworm
67. *Laphygma exigua* (Hbn.) ..... Beet armyworm
68. *Lasioderma serricorne* (Fabr.) ..... Cigarette beetle
69. *Lema trilineata californica* Schaeffer ..... Datura beetle
70. *Lepidosaphes beckii* (Newmann) ..... Purple scale
71. *Lepidosaphes gloveri* (Packard) ..... Glover's scale
72. *Liposcelis divinatorius* (Mull.) ..... Book louse
73. *Listroderes obliquus* Klug ..... Vegetable weevil
74. *Lucilia caesar* (Linn.) ..... Greenbottle fly
75. *Lucilia sericata* (Meig.) ..... Greenbottle fly
76. *Lyperosia irritans* (Linn.) ..... Horn fly
77. *Macrosiphum granarium* (Kirby) ..... Grain aphid
78. *Macrosiphum rosae* (Linn.) ..... Rose aphid
79. *Macrosiphum sanborni* Gillette ..... Chrysanthemum aphid
80. *Macrosiphum solanifolii* (Ashmead) ..... Potato aphid
81. *Megamelus davisi* Van D. ..... Water lily leafhopper
82. *Melophagus ovinus* Linn. ..... Sheep "tick"
83. *Menopon gallinae* (Linn.) ..... Common hen louse
84. *Micromyzus formosanus* (Takahashi) ..... Onion aphid
85. *Monomorium pharaonis* (Linn.) ..... Pharaoh's ant
86. *Murgantia histrionica* (Hahn) ..... Harlequin cabbage bug
87. *Musca domestica* (Linn.) ..... House fly
88. *Myzocallis kahawaluokalani* Kirkaldy ..... Crepe myrtle aphid
89. *Myzus circumflexus* (Buckton) ..... Lily aphid
90. *Myzus ornatus* Laing ..... Ornate aphid
91. *Myzus persicae* (Sulzer) ..... Green peach aphid
92. *Necrobia ruficollis* (Fairmaire) ..... Red-shouldered ham beetle
93. *Necrobia rufipes* (De Geer) ..... Red-legged ham beetle
94. *Nosopsyllus fasciatus* (Bosc.) ..... European rat flea
95. *Oestrus ovis* Linn. ..... Sheep botfly
96. *Orthezia insignis* Doug. ..... Greenhouse Orthezia
97. *Oryzaephilus surinamensis* (Linn.) ..... Saw-toothed grain beetle

98. *Pantomorus godmani* (Crotch) ..... Fuller's rose beetle
99. *Paraidemona mimica* Scudder ..... Texas grasshopper
100. *Parlatoria pergandii* Comstock ..... Chaff scale
101. *Parlatoria ziziphus* (Lucas) ..... Mediterranean scale
102. *Peridroma margaritosa* (Haworth) ..... Variegated cutworm
103. *Periplaneta americana* (Linn.) ..... American cockroach
104. *Periplaneta australasiae* (Fabr.) ..... Australian cockroach
105. *Phenacoccus gossypii* Towns. & Ckll. ..... Mexican mealybug
106. *Pieris rapae* (Linn.) ..... Cabbage worm
107. *Pinnaspis aspidistrae* (Signoret) ..... Aspidistra scale
108. *Plodia interpunctella* (Hbn.) ..... Indian meal moth
109. *Plutella maculipennis* Curtis ..... Diamond back moth
110. *Pseudococcus boninsis* (Kuwana) ..... Grey sugarcane mealybug
111. *Pseudococcus citri* (Risso) ..... Citrus mealybug
112. *Pseudococcus kraunhiae* (Kuwana) ..... Japanese mealybug
113. *Pseudococcus longispinus* (Targioni) ..... Long-tailed mealybug
114. *Pseudococcus maritimus* (Ehrhorn) ..... Grape mealybug
115. *Pseudococcus nipae* (Mask.) ..... Avocado mealybug
116. *Pulex irritans* Linn. ..... Human flea
117. *Pycnoderes quadrimaculatus* Guerin ..... Bean capsid
118. *Pyroderces rileyi* (Walsm.) ..... Pink scavenger worm. Pineapple bud moth
119. *Rhopalosiphum nymphaeae* (Linn.) ..... Waterlily aphid
120. *Rhopalosiphum prunifoliae* (Fitch) ..... Apple-grain aphid
121. *Rhopalosiphum pseudobrassicae* (Davis) ..... Turnip aphid
122. *Saissetia oleae* (Bern.) ..... Black scale
123. *Sitotroga cerealella* (Olivier) ..... Angoumois grain moth
124. *Solenopsis geminata* (Fabr.) ..... Fire ant
125. *Stictocephala festina* (Say) ..... Three-cornered alfalfa hopper
126. *Stomoxys calcitrans* (Linn.) ..... Stable fly
127. *Supella supellectilium* (Serv.) ..... Brown-banded roach
128. *Thrips tabaci* Lindeman ..... Tobacco or onion thrips
129. *Toxoptera aurantii* Fonsc. ..... Black citrus aphid
130. *Trialeurodes vaporariorum* (Westwood) ..... Greenhouse white fly
131. *Vanessa cardui* (Linn.) ..... Painted lady
132. *Vespa occidentalis* Cresson ..... Yellow jacket
133. *Xenopsylla cheopis* (Roths.) ..... Indian rat flea
134. *Xylocopa varipuncta* Patton ..... Carpenter bee

The Fiji Disease Project In Samoa

By J. P. Martin

An account of the Fiji-disease project on Samoa as to why and when it was established is given and the facilities for testing Hawaiian-grown canes of commercial promise against Fiji disease at the substation are described and illustrated. The various cane diseases occurring in Samoa are listed and a short description of native canes which are grown for eating purposes and which were collected and planted in a museum plot at the substation is included.

Of all the foreign sugar-cane diseases, Fiji disease offers the greatest threat to the Hawaiian sugar industry. At present the commercial varieties now grown in Hawaii are highly susceptible to the disease. The vector which transmits the disease, the sugar-cane leafhopper, *Perkinsiella saccharicida* Kirk., is established here.

For many years Dr. H. L. Lyon, Director, the pathologists, and the entomologist of this Station, as well as others within the sugar industry, have realized the necessity of having a substation where the newly propagated Hawaiian canes possessing commercial qualities might be grown in association with canes affected with Fiji disease so that their relative degree of resistance to the disease could be determined. After considering all possible locations for such a substation, American Samoa was selected. Fiji disease occurs in Samoa and conditions there are favorable for its development and spread.

Shortly after the end of the war this project was again taken up by Dr. Lyon and in April 1946 he and W. W. G. Moir, Chairman, Experiment Station Committee, visited American Samoa, selected a suitable site for a substation, and made the necessary arrangements with the U. S. Navy to lease the land, and for the construction of living quarters on the property. The area selected consists of approximately eight acres at Vailoatai, near Leone Village, on the south side of Tutuila, and 14 miles west of Pago Pago.

The living quarters were completed in due time (Figs. 1 and 2) and F. C. Hadden arrived in Samoa October 8, 1946 to take charge. The details pertaining to equipment and supplies for operating the substation were handled by staff members in Honolulu and Mr. Hadden in Samoa. A sufficient area of land was cleared (Figs. 3, 4, 5 and 6) for planting the Hawaiian-propagated canes and a small vegetable garden. With the heavy rainfall in Samoa, it is anticipated that irrigation will not be necessary for normal cane growth. The cane area is almost level and has a well-drained soil (Figs. 4 and 5).

On December 30, 1946 C. A. Wismer and the writer left Honolulu by plane for Samoa. A number of the Hawaiian canes were taken to Samoa at this time. While en route it was possible to spend one day studying Fiji, downy mildew and other diseases at Nausori Mill Co., Ltd. in Fiji. We arrived in Samoa January 2, 1947 and Mr. Hadden met us at the Tafuna airfield. The substation was found to be exceptionally well organized and to be operating in a most efficient manner. We greatly appreciate the fine work accomplished by Mr. Hadden in getting the

Fiji disease project underway. Mr. Hadden, due to poor health, left Samoa for San Francisco January 14, 1947, for several month's sick leave on the mainland and was relieved by Mr. Wismer. The writer left Samoa January 14, 1947, to return to Honolulu by way of Fiji; several days were spent in Fiji studying cane diseases, with special attention being devoted to Fiji disease and downy mildew and their field control.

In conducting a Fiji disease varietal resistance test one method is to plant every third row with diseased cuttings of a susceptible variety such as Kassoer; the two rows between the diseased rows are then planted with cuttings of the varieties to be tested. By using this scheme every variety being tested is in contact with diseased material. The only method known of transmitting the disease is by the sugar-cane leafhopper, thus it is essential in such a test to have a large population of leafhoppers present at all times. It has also been demonstrated that canes making a normal growth are more susceptible than those making a slow growth and every attempt is made to create as favorable growing conditions as possible while the varieties are being tested.

The following Hawaiian cane varieties, with the number of cuttings of each, were taken to Samoa and planted January 3, 1947 (Fig. 4).

32-1063	(4)	39-723	(2)
32-8560	(4)	39-3633	(2)
37-1933	(4)	39-7028	(2)
37-7202	(2)	40-44	(2)
38-2915	(2)	Kassoer	(20)

Each cutting was planted six feet apart in rows, with every third row similarly planted with cuttings taken from local cane plants affected with Fiji disease. In Samoa there are many small plantings of sugar cane scattered over the island. These plantings are located usually near villages. The variety grown most extensively has a purple, small-to-medium-size stalk and is known as *Tolo fua lau*. It is used chiefly for thatching. Almost without exception the 15 to 20 small patches examined were found to be badly affected with Fiji disease (Figs. 7 and 8) and it was from such areas that we collected the diseased material for contact planting with the Hawaiian canes. Upon entering a small patch of cane the stools affected with Fiji disease were easily spotted because of their very stunted appearance; leaf galls were always present on this type of material. In patches of badly diseased cane leaf galls were often found on cane which appeared to be making a normal growth; in such instances sufficient time had not elapsed since the plants contracted the disease for the stunting effect to manifest itself. Cuttings taken from plants in this condition have a better chance to germinate than from plants which are severely stunted in growth.

Mr. Wismer reported at the end of January 1947 that with the exception of one cutting of Kassoer, all cuttings of the Hawaiian varieties planted in Samoa had germinated and the canes were making a good growth. The cuttings of *Tolo fua lau* (Figs. 8 and 9) selected from plants affected with Fiji disease germinated fairly well but the growth had been slow; Mr. Wismer states that "Seedpieces from the lower portion of the stalk of this diseased material seem to have given a higher percentage of germination than seedpieces taken from the upper portions of the stalk . . . Diseased material for planting has been obtained in lots of from 25 to 100 stalks according to the size of the patch . . . Eleven rows have been planted to

date. Each row is nearly 300 feet long and the rows are spaced 18 feet apart." Cuttings of additional Hawaiian varieties to be tested will be sent to Samoa as soon as transportation is available and planted between the diseased rows of cane; all rows will be six feet apart and each Hawaiian variety being tested will be in contact with diseased cane. Having the diseased material already established when the Hawaiian varieties are planted will make for a more thorough test.

During our inspections of the various local plantings in Samoa the leafhopper, *Perkinsiella vitiensis* Kirk., was found to be very numerous. A large population of insects is essential for transmitting Fiji disease from diseased to healthy canes in a varietal resistance test. Another essential factor in such a test is to have a high incidence of the disease present.

In a letter from Mr. Wismer, dated February 9, 1947, he stated that the diseased material of *Tolo fua lau* planted January 7, 1947, in association with the Hawaiian canes, has produced numerous galls of Fiji disease on the leaves and that leafhoppers are already established on all varieties. It is evident that all factors necessary for determining the relative resistance of the Hawaiian varieties to Fiji disease are present and that these tests should yield very definite results. The progress to date on this project has been most encouraging.

Cane Diseases Observed In Samoa:

With the exception of Fiji disease, which was very common and doing considerable damage on *Tolo fua lau,* the various canes inspected were found to be quite free from symptoms of the major cane diseases. The various diseases noted are discussed.

Ring spot was found on the older leaves of a number of varieties and in some instances was responsible for some leaf damage and a premature dying of the leaves. Several varieties manifested definite leaf symptoms of pokkah boeng, but no cases were noted where the disease had killed the plants. A small amount of brown stripe was noted; the disease at this time was considered of minor importance. Leaf freckle affecting chiefly the older leaves was observed in several instances.

A rather high incidence of red rot disease in the midribs of the leaves was present. The sugar-cane leafhopper, *P. vitiensis,* lays its eggs in the midribs of the leaves and to some extent in the cane stalks. The red rot organism gains entrance into the leaf through the injuries caused by the leafhoppers. A small amount of red rot was observed in cane stalks affected with Fiji disease from which cuttings were selected and planted in the Fiji disease test area.

The above diseases were recorded by Mr. Wismer and the writer while the latter was in Samoa. Mr. Wismer in his report for January 1947 stated that he observed chlorotic streak disease on leaves of several stools of cane growing in three different localities near the village of Leone and in one area near Vaitogi. Cuttings were selected from the stalks affected with chlorotic streak and were planted next to the museum canes at Vailoatai.

So far gumming, leaf scald and downy mildew diseases have not been reported in Samoa. The fact that these diseases occur in Fiji leads one to believe that they may also occur in Samoa and for this reason the canes in Samoa have been carefully inspected for symptoms of these diseases. Should they be found in Samoa it would then be possible to test the Hawaiian canes against downy mildew and gumming as well as Fiji disease at our substation; the results of such tests would

give additional information on the relative degree of resistance of the Hawaiian canes to three major foreign diseases which do not occur in Hawaii.

Museum Canes:

While visiting the various cane patches in the different areas on Tutuila a number of interesting canes were noted. Several of these canes were grown for eating purposes and of those examined none was found to be affected with Fiji disease; in general the majority were large-stalk canes and were exceptionally free from symptoms of disease. Realizing that these varieties may give valuable information in our Fiji disease research, cuttings of six varieties were collected and planted (Figs. 10 and 11) January 9-10, 1947, in an area where additional canes might later be planted. On January 16, 1947, the cuttings were replanted in a more suitable area and were spaced eight feet apart. A short description of the canes planted in the museum plot follows:

No. 1. A cane with a purplish, medium-size stalk, collected at the Island Government Farm. This variety is very similar to Co. 290, one of the four varieties (the others being P.O.J. 36, P.O.J. 213 and Co. 213) sent to Samoa by this Station in 1939. Since these varieties are highly resistant to Fiji disease they might replace the variety which is now being used for thatching *(Tolo fua lau)* which is highly susceptible to Fiji disease.

No. 2. A cane with a large dark-colored stalk, somewhat similar to Badila, with broad leaves. The internodes were much longer than those of Badila. This variety was used for eating and the name *Tolo uli* was given to us by the grower. Collected at the village of Nuuli.

No. 3. A cane with a large light-reddish stalk with long broad leaves, known as *Tolo mumu* (red), was also collected at Nuuli. This variety was grown for its eating qualities.

No. 4. A cane with a large leaf and stalk, the latter being light-purplish with lighter purplish stripes. This was an eating cane and was collected at the village of Aua under the name of *Vae vae ula.*

No. 5. A large-stalk cane, light-rose in color, with dark greenish stripes, with large broad leaves was another eating variety collected at Aua Village.

No. 6. A cane with a large light-yellowish-green stalk somewhat similar to Lahaina was collected at Aua Village under the name of *Tolo limu.* This was also an eating cane.

General:

In presenting the following brief discussion on the island of Tutuila the writer has drawn upon the publication entitled, *American Samoa, A General Report by the Governor,* published by the U. S. Government Printing Office, Washington, D. C., 1927.

The Samoan Islands forming an irregular chain lie between latitudes 13°26′ and 14°31′ South and longitudes 168°11′ and 172°48′ West. Tutuila, the main island of American Samoa is about six miles wide at the widest part, and 18 miles in length, or approximately 40 square miles. The island is very mountainous and the mountains are very precipitous and heavily wooded. There is very little flat land which can be used for farming and what there is occurs mostly in the southwestern part of the island. Pago Pago Bay is the best harbor in the South Seas and on its edge is situated the United States Naval Station. The highest mountain, Matafao Peak 2,141 feet, is located in the center of Tutuila; Mount Pioa, 1,717 feet in

height, commonly referred to as the Rainmaker is on the east side of Pago Pago Bay.

Usually between May and November strong southeast winds, often of hurricane proportions, occur and cause severe damage to the principal food crops (taro, breadfruit, bananas and coconuts). The yearly average rainfall from 1900 to 1926 was 197.15 inches, with February showing the greatest monthly average (21.73 inches) and August the least (7.81 inches). Over the same 26-year period, February was the hottest month with an average temperature of 82.28° F. and July the coolest, 80.21° F. The relative humidity is always high, 70 to 90 per cent during the wet season and 40 to 60 per cent during the dry season. Such a tropical environment is most conducive for the growth of plant life, making the entire island a mass of vegetation.

The fruits grown mostly are: orange, lemon, lime, mango, avocado, papaya (Esi), pineapple and banana (Fa'i). The main vegetables are: taro (Talo), breadfruit ('Ulu), and yam (Ufi). In a few gardens are found some of the temperate-zone vegetables such as carrots, beets, tomatoes, lettuce, corn, eggplant, beans, onions and sweet potatoes ('Umala). The coconut (Niu) is one of the most important crops and is extensively cultivated — it gives "meat, drink, and shelter to the Samoans." Some copra is exported. Sugar cane (Tolo), as already mentioned, is found in many gardens. A few pictures of general interest taken in Samoa are shown in Figs. 14, 15, 16, and 17.

We greatly appreciate the interest shown by, and the cooperation received from Captain H. A. Houser, U. S. Navy, Governor of American Samoa, and other Navy personnel in getting the substation established.

Fig. 1. Living quarters at Vailoatai Substation in Samoa, with garage, laboratory, servant's room, and storeroom on the ground floor.

Fig. 2. Side and end views of the dwelling house.

Fig. 3. The cane area as seen from the living quarters.

Fig. 4. The Hawaiian canes now being tested against Fiji disease were planted at the extreme right of this field. A corner of the house is shown in the upper left part of the picture.

Fig. 5. Another general view of the cane area with the house in the upper right corner of the picture.

Fig. 6. Looking toward Barstow School from the substation.

Fig. 7. A typical patch of *Tolo fua lau*. This variety is used for thatching and is highly susceptible to Fiji disease. Ukulele, an employee at the substation, is holding a plant affected with Fiji disease.

Fig. 8. Selecting cuttings from *Tolo fua lau* affected with Fiji disease for contact planting with the Hawaiian canes.

Fig. 9. Stalks of *Tolo fua lau* affected with Fiji disease. Note marked stunting of young leaves. C. A. Wismer holding diseased plants.

Fig. 10. The museum plot where a few cuttings of each of the different local canes are planted.

Fig. 11. Planting Samoan canes in the museum plot.

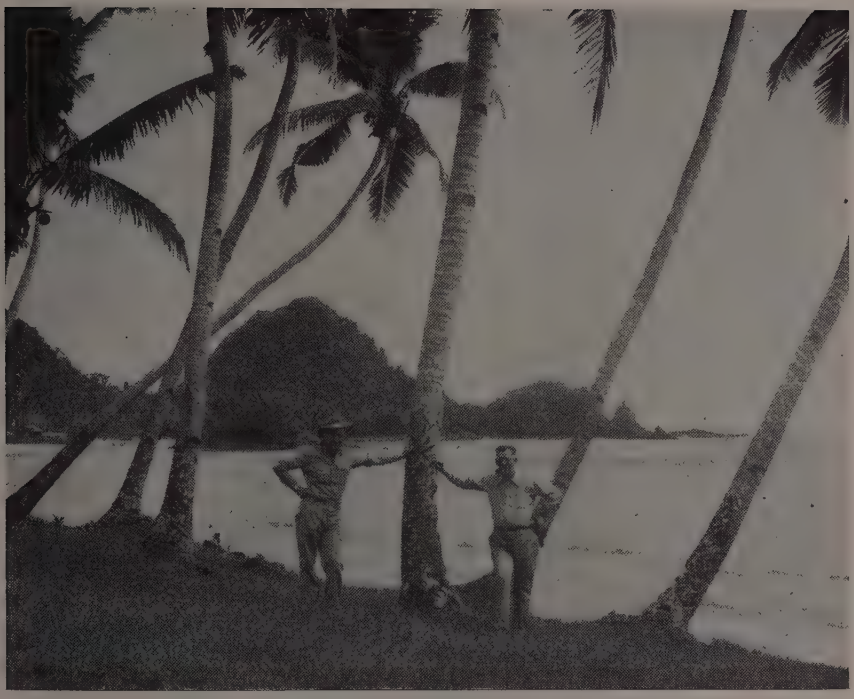


Fig. 12. The coast line beyond the village of Leone.

Fig. 13. The shoreline looking toward the substation.

Fig. 14. Showing the entrance to Pago Pago harbor with Flower Pot Island in the foreground and the Rainmaker (Pioa) in the background.

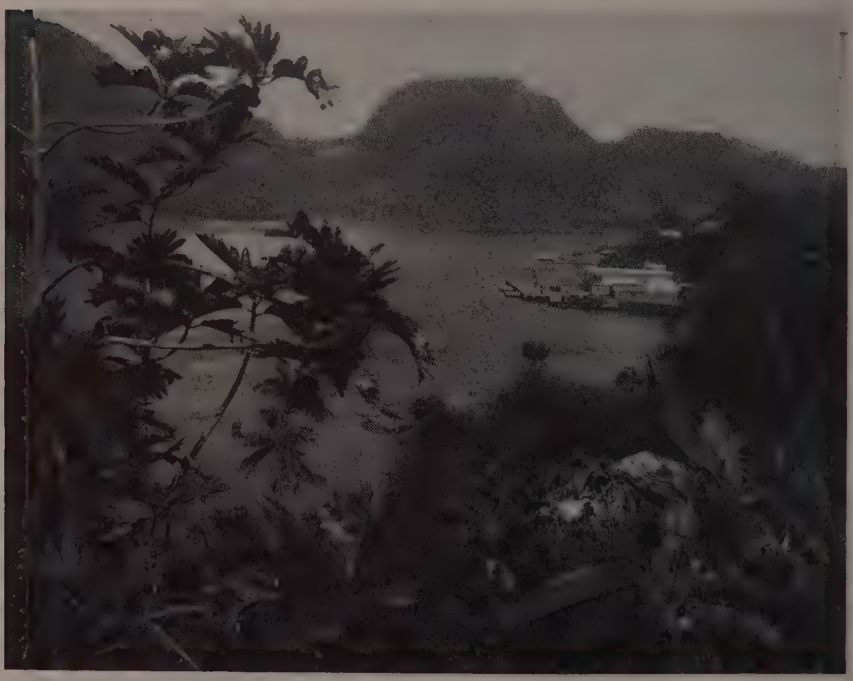


Fig. 15. Pago Pago harbor with the Naval Station on the right and the Rainmaker in the distance.

Fig. 16. Wind damage to banana plants at the substation.

Fig. 17. Sunset.

Fiji Disease of Sugar Cane

By J. P. Martin

In this article particular attention has been devoted to the history, description, transmission, economic importance and the control of Fiji disease which is considered the most serious of all known sugar-cane diseases. Accompanying this article is a listing of a large number of commercial and/or breeding canes of the world wherein the relative resistance of each variety to Fiji disease is given.

Some forty years ago a new disease causing a marked stunting of cane plants was observed in Fiji and it very soon became known as Fiji disease. By 1908-09 the incidence of the disease was so great that the entire sugar industry in Fiji was threatened with ruin. The Colonial Sugar Refining Company, Ltd., with headquarters in Sydney, Australia, realized that definite field-control measures were essential if the industry in Fiji was to survive. D. S. North, then Field Chemist, later Plant Pathologist (now retired) of the Company, was sent from Australia to study the disease. His careful field studies during those early years yielded valuable information pertaining to the identification and ways and means of controlling the disease; North's (7) unpublished reports of 1910 show that it was extremely widespread and was causing serious financial losses.

In 1910 the late Frederic Muir, entomologist of this Experiment Station, upon his return from British New Guinea where he had been collecting parasites for the biological control of the sugar-cane beetle borer in Hawaii, visited Fiji and was greatly impressed with the seriousness of Fiji disease. He brought back photographs and preserved specimens of the disease to Dr. H. L. Lyon, then Pathologist, now Director, Experiment Station, H.S.P.A., for study. In *The Hawaiian Planters' Record* for 1910 Lyon (3) described and illustrated the disease in an article entitled "A New Cane Disease Now Epidemic in Fiji." This is one of the first, if not the first, published account of Fiji disease. Some of the specimens collected by Muir are still preserved in the Pathology museum. During 1910-11 Lyon visited Fiji and Java in order to investigate Fiji and sereh diseases as well as other cane diseases in these two countries; he secured preserved specimen material and excellent photographs of the major diseases. Upon his return to Honolulu careful histological and cytological studies were made of the Fiji disease material collected. During 1911 and 1912 North spent nine months here working with Lyon on cane diseases in general but with special emphasis on histological studies of Fiji disease.

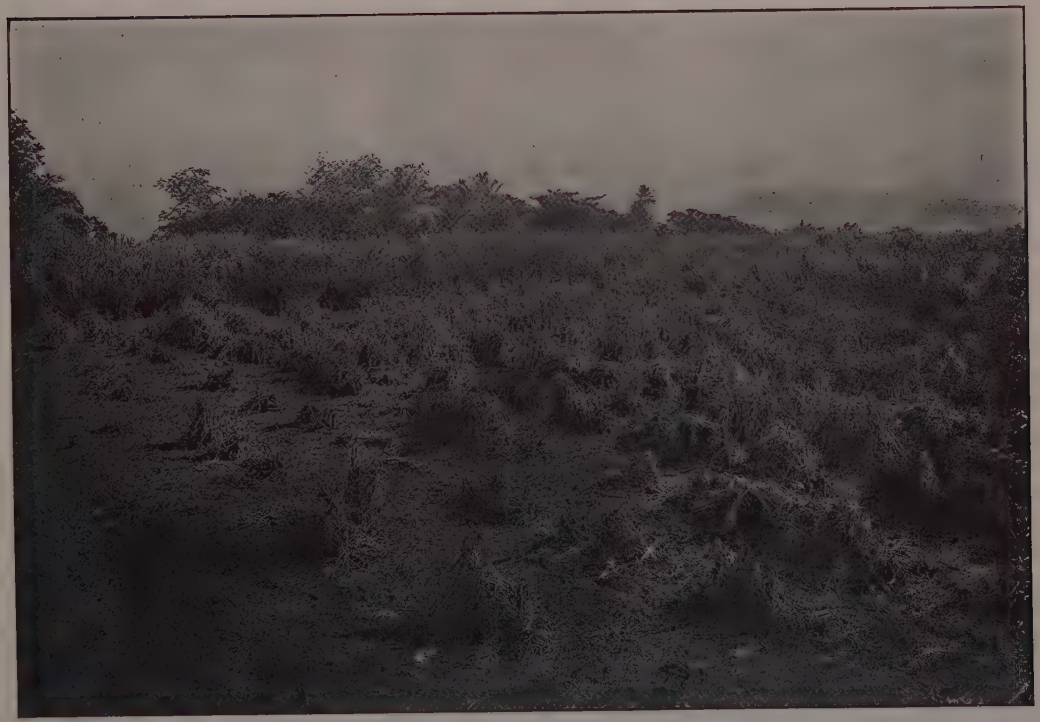


Fig. 1. Plant cane, seventeen months old, in Fiji affected with Fiji disease. Every stool of the variety in the foreground is dead. Of the variety in the background to the left, 80 per cent of the stools are affected, but the growth is not as yet seriously depressed.
After Lyon. Photo by North, 1910.

The symptoms by which Fiji disease is recognized are definite and clear cut. One of the first symptoms is a marked dwarfing or stunting of the plant (Figs. 1 and 2). Once the plant is affected it makes little or no growth thereafter (Figs. 3, 4, and 5). The young leaves are very much shortened and frequently have the appearance of having been nipped or eaten by an animal (Figs. 6 and 7). There are other factors which may cause a stunting of the cane plant, such as pokkah boeng, malnutrition and poor drainage. The second and most certain diagnostic symptom by which the disease is recognized is the presence of small elongated galls on the lower surface of the cane leaf (Figs. 8 and 9). The galls are from 1/32 to 1/16 of an inch in width and anywhere from a fraction (⅛ inch) to several inches in length. They are usually smooth and of a lighter green than the leaf and always extend with the leaf veins or vascular bundles of the leaf. In very advanced stages of the disease the galls may become slightly ruptured and assume a brownish appearance (Fig. 9). Fiji disease affects primarily the phloem of the vascular bundle and causes a cell proliferation. The affected cells become stimulated and produce an abnormal growth which is manifested in the form of elongated galls immediately below the vascular bundle or on the phloem side of the bundle (Fig. 10). Since Fiji disease is chiefly a vascular disease and since it affects the phloem which is situated in the lower part of the bundle, the development of the galls can only take place on the lower surface of the cane leaf (Figs. 10 and 11). No other cane disease is known to cause galls on the lower surfaces of the cane leaves and because of this unique feature the presence of the galls is the one critical symptom before a positive diagnosis of the disease can be made. Any doubtful or questionable case should be examined from time to time since the leaf galls may not have had time to develop when the gross symptoms, particularly the stunting effect, of the disease were first observed. Lyon showed that the galls are also produced in the vascular bundles of the stems of affected plants and that excessive multiplication of the cells of the phloem takes place. This fact was brought out only after very careful histological sections of affected stems were prepared and studied. Following 1911 Lyon discussed his findings on Fiji, sereh and other foreign diseases in his annual reports and pointed out that every effort should be made to exclude such diseases from Hawaii. In 1921 Lyon (4) published his studies on Fiji and sereh diseases. Mungomery and Bell (5) in a paper on the transmission of Fiji disease in 1933 state that, ". . . it is to his [Lyon's] published report that sugar cane pathologists owe much of their knowledge of these two diseases." Detailed cytological and histological studies of Fiji disease were conducted by Lyon (4) and Kunkel (2) and it is from these studies that the effects of the disease on the various plant parts were determined. The presence of X-bodies or intracellular bodies in cells of affected plants was first described and illustrated by Lyon (3) in 1910 and again by Kunkel (2) in 1924. They found that the cytoplasm of infected cells was more dense and stained more deeply than that in healthy cells.

The disease now occurs in Fiji, Australia, Philippine Islands, Solomon Islands, New Guinea, New Britain and American Samoa. It is likely that the disease spread from New Guinea to these sugar-producing countries by cuttings. Fiji disease is regarded as the most serious of all sugar cane diseases. In some instances losses have been as high as 80 to 90 per cent. There are very few varieties which are immune. However, there are a number of varieties which are commercially resistant

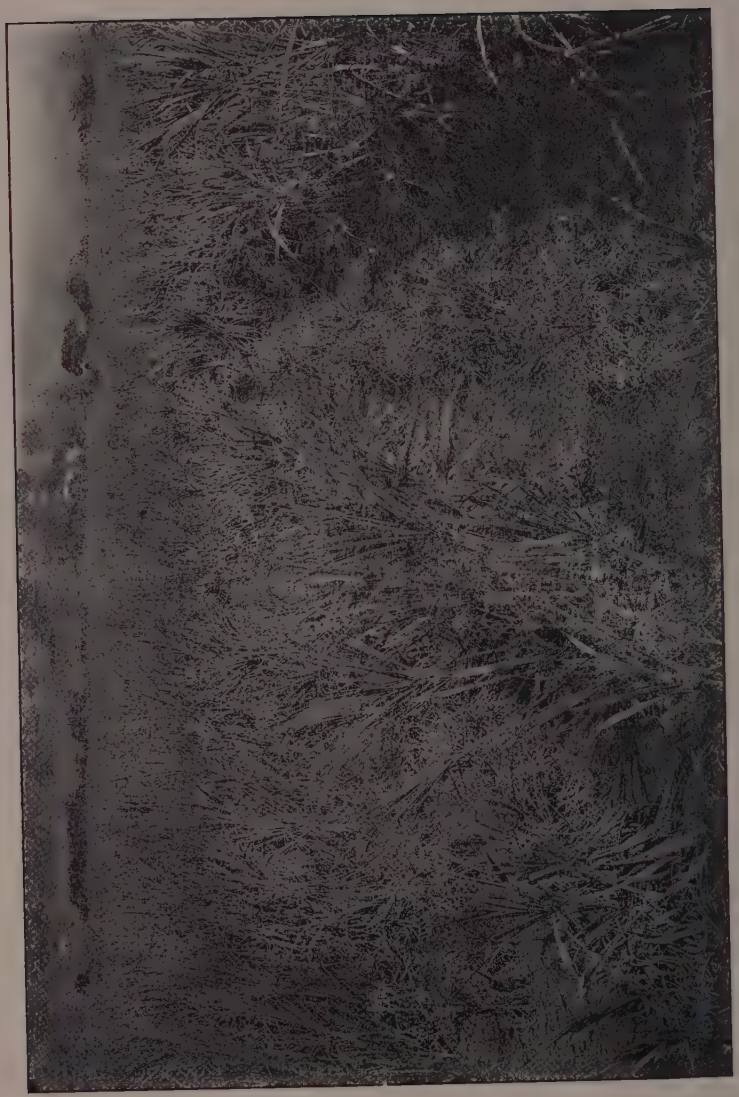


Fig. 2. Each of the four varieties, first ratoons, in the center is badly affected with Fiji disease. More resistant varieties are shown on either side. After Lyon. Photo by North, 1910.

and can be successfully grown in regions where susceptible varieties have failed.

Working independently, Mungomery and Bell (5), in Queensland and Ocfemia (8) in the Philippines demonstrated, in 1932, that the disease was transmitted by nymphs of the sugar-cane leafhopper. In experimental studies the disease has not been transmitted by adults of the sugar-cane leafhopper, nor has it been demonstrated that the virus passes through the egg stage of the leafhopper. In Australia the transmission of the disease was carried out with the leafhopper *Perkinsiella saccharicida* Kirk., while in the Philippines, Ocfemia used the species *P. vastatrix*

Fig. 3. Ratoons of Badila cane at Rarawai in Fiji (1947) affected with Fiji disease. A portion of the cane in the center line has been killed by the disease.

Breddin. The species found in Australia also occurs in Hawaii. In Fiji and American Samoa the leafhopper which transmits the disease is *P. vitiensis* Kirk. Prior to 1932 the method of transmission of the disease from plant to plant was not known. In his early studies North clearly demonstrated that when cuttings from diseased plants were planted the new growth was invariably diseased and because of this fact one of the first control measures was to select planting material from healthy plants only. The leafhopper or vector of the disease after feeding on a diseased plant often moves to a healthy plant and again starts feeding, and in so doing, it actually inoculates the healthy plant with the virus which it acquired from the diseased plant. The leafhopper feeds mainly on the tissues which go to make up the phloem, the sieve tubes and companion cells, possibly because the plant foods, chiefly sugars and other carbohydrates, are confined in the phloem after they have been elaborated in the leaf and are being translocated to other parts of the plant.

Fiji disease is an infectious systemic disease, that is, when the cane plant is affected, the entity or virus which causes the disease occurs in all parts of the

plant, and when cuttings are taken from diseased plants and planted they give rise to diseased plants.

In addition to sugar cane, Fiji disease was found to be serious on a wild reed-like cane, "Veico" (pronounced Vetho, and undoubtedly *Saccharum spontaneum*) by Lyon January 9, 1911 in the Nandi district of Fiji. As a matter of interest symptoms similar to those of Fiji disease, especially leaf symptoms suggesting galls on the lower leaf surfaces, were noted by Hadden, Wismer and Martin on Job's

Fig. 4. The blank spaces and the depressed growth in this field of Negros Purple at Los Banos, P. I. (1929) have been caused by Fiji disease.

tears, *Coix lachryma-Jobi,* in Samoa (1947); further studies on this observation are to be made.

The disease has been known to be introduced from one country to another by sugar-cane cuttings. During 1930 several cane varieties were introduced into Java from the Philippines through quarantine maintained in Java at Ranoe Daroengan. After the varieties had been growing for a short period Fiji disease developed on two varieties, C. A. 12735 and C. 147; all canes were immediately destroyed. This is an excellent example where a quarantine of imported varieties proved extremely valuable to the Java sugar industry. Fiji disease does not occur in Java.

The canes collected in 1928 in New Guinea by Brandes, Pemberton and Jeswiet were taken to Sydney, New South Wales, and planted under quarantine. One case of Fiji disease developed on the variety No. 286 while under quarantine, and it was felt that the disease had resulted from primary infection, that is the stalk from which the cutting had been selected in New Guinea was diseased without the

manifestation of any external symptoms. As in Java, this is another instance where a definite quarantine proved highly efficacious in intercepting a disease.

During recent studies in Australia by Mungomery (6) it was shown that infective leafhoppers (nymphs) can transmit the disease to healthy plants within a feeding period of 20 hours and that such insects may act as vectors or carriers for 16 days. It was also shown that the disease could be transmitted by the leafhopper

Fig. 5. A stool of POJ 2727 affected with Fiji disease, Calamba Sugar Estate, Luzon, P. I. (1929). Note marked contrast in growth between diseased and healthy cane in the background.

through the leaf sheath and unrolled leaf spindle. The incubation period or time required for the first symptoms to be noted after infective leafhoppers were placed on healthy, normal growing cane was 29 days; on poorly growing cane or in cases where cane growth was depressed due to environmental conditions, the incubation period increased to 236 days.

The incidence of Fiji disease varies directly with the population of leafhoppers;

where a good biological control of the insects is maintained the spread of the disease is comparatively slow. Where varieties susceptible to the disease are grown and where the population of leafhoppers is not under control a high incidence of Fiji disease can be expected.

Fiji disease *per se* has two marked effects on the cane plant. On the very susceptible varieties not only is the cane badly stunted but a large portion is killed outright (Fig. 1). On the more tolerant varieties the cane is not necessarily killed but the growth is greatly retarded (Fig. 5). Where healthy cane would normally

Fig. 6. The variety Galba attacked by Fiji disease at Nausori, Fiji (1947). The shortening effect of cane leaves and depressed growth of the stalk are definite symptoms of the disease. C. A. Wismer holding diseased stalk.

yield 70 to 80 tons per acre diseased cane of the same variety might only yield 7 to 10 tons per acre depending entirely on the degree of infection within the variety.

In a number of instances resistant varieties frequently manifest leaf galls with little or no apparent stunting of the cane itself. The potential danger associated with these varieties is greater than with susceptible varieties. In the case of the former they may act as carriers of Fiji disease with few external manifestations of the disease itself. Such canes always require much more careful consideration especially when imported than do the more susceptible varieties. The susceptible

varieties, because of their stunted growth, are much more readily spotted in a field than the resistant varieties.

In Australia very extensive studies of Fiji disease have been carried out by North, Bell (1), Baber and Mungomery, especially in relation to its transmission, and field control. Particular attention has been devoted to varietal resistance tests, wherein varieties possessing commercial possibilities are tested in order to determine their relative degree of resistance to Fiji disease. Since the only method known of transmitting the disease is by the sugar-cane leafhopper, the varieties to be

Fig. 7. The effect of Fiji disease on a stalk of Badila cane. The leaves manifest a torn appearance and are very much shortened and crumpled. Photo by North.

tested are planted in contact with one or more highly susceptible varieties. Every effort is made to create growing conditions as favorable as possible while the canes are being tested. It has been shown that cane making a slow growth may be

susceptible to the disease but the time required for the first symptoms of the disease to develop is very much longer than it is on cane making a normal rate of growth. In conducting varietal resistance tests it is highly essential to have a large population of leafhoppers present as well as a high incidence of the disease. In these tests, one satisfactory method has been to plant every third row with diseased cuttings of a susceptible variety such as Kassoer or Uba and the rows in between with the varieties to be tested. With this plan each variety under test is in contact with diseased material. Since the severity of the disease increases with the ratoons, the results of such tests are never conclusive with the plant crop; the tests must be carried through at least one ratoon crop.

During 1938 cane cuttings of six of the more promising commercial Hawaiian

Fig. 8. Galls of Fiji disease on the lower leaf surface of Yellow Caledonia, at Broadwater, N.S.W. Australia, 1929.

canes, listed in the table below, were sent to the Bureau of Experiment Stations, Brisbane, Queensland, to test them against Fiji, downy mildew and gumming diseases. These tests were carried out under the supervision of A. F. Bell. After several years which were required to thoroughly test the varieties, the following results were forwarded to us by Mr. Bell.

Variety	Fiji Disease	Downy Mildew	Gumming Disease
28-4291	—	+	+
31-2484	—	+	+
31-2806	—	+	
32-1063	—		+
32-3575	—		—
32-8560	—	+	+

From the above table it is very apparent that the commercial varieties now grown in Hawaii are highly susceptible to Fiji disease. The symbols used in the above table for expressing the relative degree of resistance of a variety to the diseases are explained at the beginning of the following table. As already men-

Fig. 9. Typical galls of Fiji disease on H 109 which is highly susceptible to the disease. Photo by Philippine Bureau of Science, P. I.

tioned the vector of Fiji disease, the sugar-cane leafhopper, *P. saccharicida* Kirk., occurs in Hawaii; it is by no means common in the cane fields, its control having been effected by means of parasites. If one infective leafhopper should arrive on a plane from Samoa, Fiji or the Philippines and start feeding on one of our canes

there would be every chance for Fiji disease to become established in Hawaii. Once the virus becomes established here the leafhoppers already present would spread the disease. During the years when travel was entirely by steamer it was very unlikely that infective hoppers would survive the journey because of the time interval. Leafhoppers can live only for a few days without proper food. With airfields now bordering plantation fields a disease carried by an insect has a much better opportunity of becoming established than heretofore. The faster and more

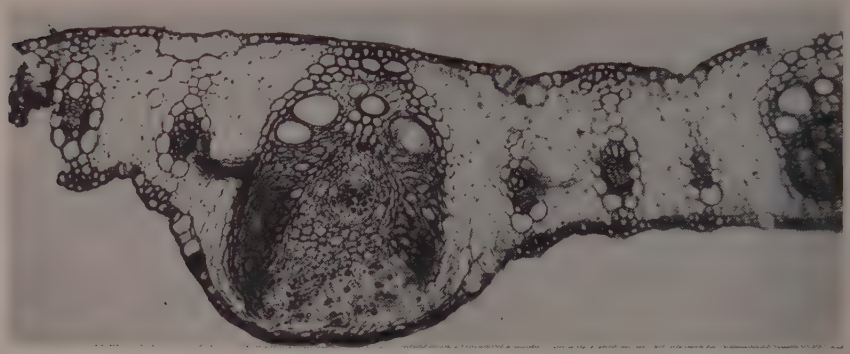


Fig. 10. Cross section of a leaf gall of Fiji disease. The gall is produced on the lower leaf surface by an abnormal growth, chiefly of the phloem cells. After Kunkel.

frequent trans-Pacific air service between Hawaii and those countries where foreign diseases occur present a major problem of concern to the industry.

Hawaii's isolated geographical position in relation to other sugar-producing countries and the rigid quarantine imposed on the importation of new varieties have been largely responsible for the exclusion of the major foreign diseases. Fiji disease does not occur in Hawaii; however, during the war years the chances for it or any new disease becoming established were greatly increased. These chances are also going to be great during the years to follow, now that air travel is becoming a part of our everyday life. As the result of present circumstances we must depend more than ever upon quarantine measures for keeping foreign diseases and disease-carrying insects out of Hawaii.

The major field-control measures of Fiji disease may be briefly summarized as follows:

1. Plant varieties which are highly resistant to the disease.
2. Rogue and destroy all diseased plants in the fields.
3. Plant cuttings taken from healthy plants only.
4. Reduce the number of susceptible varieties as quickly as possible.
5. Maintain a good control of the sugar-cane leafhopper.

The information presented in the following table, giving the relative degree of resistance of a large number of sugar-cane varieties to Fiji disease, has been furnished by Mr. Bell and it is with his permission that this information is being published at this time. The relative degree of resistance of each variety to Fiji disease has been determined chiefly from varietal resistance tests conducted over a period of years and to some extent from field observations of a variety having been exposed to natural infection under different environmental conditions.

The Relative Degree of Resistance of Sugar Cane Varieties to Fiji Disease

Key as used by the Bureau of Sugar Experiment Stations, Brisbane, Australia. Furnished by A. F. Bell in his letter of May 9, 1946 to J. P. M.

1 = Highly resistant; may be grown in the presence of the disease without precautions.
1-2 = Resistant.
2 = Medium resistant; may be grown in the presence of the disease providing suitable precautions are taken.
2-3 = Susceptible.
3 = Highly susceptible; can only be grown when particular precautions are taken.

Key as used by Expt. Sta. H.S.P.A.

++ Very highly resistant
\+ Highly resistant
= Average
— Highly susceptible
—— Very highly susceptible

Cane Varieties		Degree of Resistance	
Atlas		1-2	+
Badila (N.G.15)	H*	1-2	+
BH 10-12	H		=
C.P. 29.116		2-3 (?)	—
Chunnee	H		+
Co. 205	H	2	=
Co. 210	H	1	++
Co. 244		1	++
Co. 270	H	1	++
Co. 281	H	2	=
Co. 290	H	1	++
Co. 352		1	++

*H signifies that this variety occurs in Hawaii.

Cane Varieties		Degree of Resistance	
Co. 355		1	++
Co. 356		1	++
Co. 364		1-2	+
Co. 419		3	——
Comus		2-3	—
D 1135	H	2-3	—
E. K. 28	H	3	——
Erianthus	H	1	++
Eros		2	=
H 109	H	3	——
28-4291	H	3	——
31-1389	H	2-3	—
31-2484	H	3	——
31-2806	H	3	——
32-1063	H	3	——
32-3575	H	3	——
32-8560	H	3	——
26 C 189	H	3	——
Hind's Special	H	1	++
H. Q. 5		3	——
H. Q. 285		1-2	+
H. Q. 426		3	——
Jason		1	++

Cane Varieties		Degree of Resistance	
Juno		2-3	—
Kassoer	H	3	— —
Katha	H	1	+ +
Korpi (14N.G.124)	H	2	=
Korpi			+
Loethers		1-2	+
M. 189		2-3	—
M. 1900 S	H	2-3	—
Mahona (N.G.22)	H	2	=
Malabar	H	3	— —
N.G.16		2-3	—
28 N.G.7		1	+ +
28 N.G.49		3	— —
28 N.G.101		1	+ +
28 N.G.201		3	— —
28 N.G.251		1	+ +
Oramboo (14 N.G.190)		2	=
Oramboo			+
POJ 36	H	1	+ +
POJ 100	H	1-2	+
POJ 213	H	1	+ +
POJ 234	H	1	+ +
POJ 979	H	1	+ +
POJ 2364	H	3	— —
POJ 2379	H	1-2	+
POJ 2714	H	3	— —
POJ 2722	H	1-2	+
POJ 2725	H	3	— —
POJ 2727	H	3	— —
POJ 2747	H	3	— —
POJ 2875		3	— —
POJ 2878	H	3	— —
POJ 2883	H	3	— —
POJ 2940	H	3	— —
Q. 2		2	=
Q. 10		2-3	—
Q. 20		1-2	+
Q. 25		3	— —
Q. 26		1	+ +
Q. 27		1	+ +
Q. 28		1	+ +
Q. 42		2	=
Q. 44		1	+ +
Q. 45		3	— —
Q. 47		1-2	+
Q. 48		1-2	+
Q. 49		1	+ +
Q. 51		2	=
Q. 52		2	=
Q. 813			+
R.P. 8		3	— —
S.C. 12/4	H	2	=
S.J. 7		1	+ +
S. spont. Tank		1	+ +
S. spont. Burma	H	1	+ +
Saretha		1	+ +

Cane Varieties		Degree of Resistance	
Toledo	H	1	+ +
Trojan		1	+ +
U.D. 1	H	3	— —
U.D. 39	H	3	— —
Uba	H	3	— —
Uba Marot		1	+ +

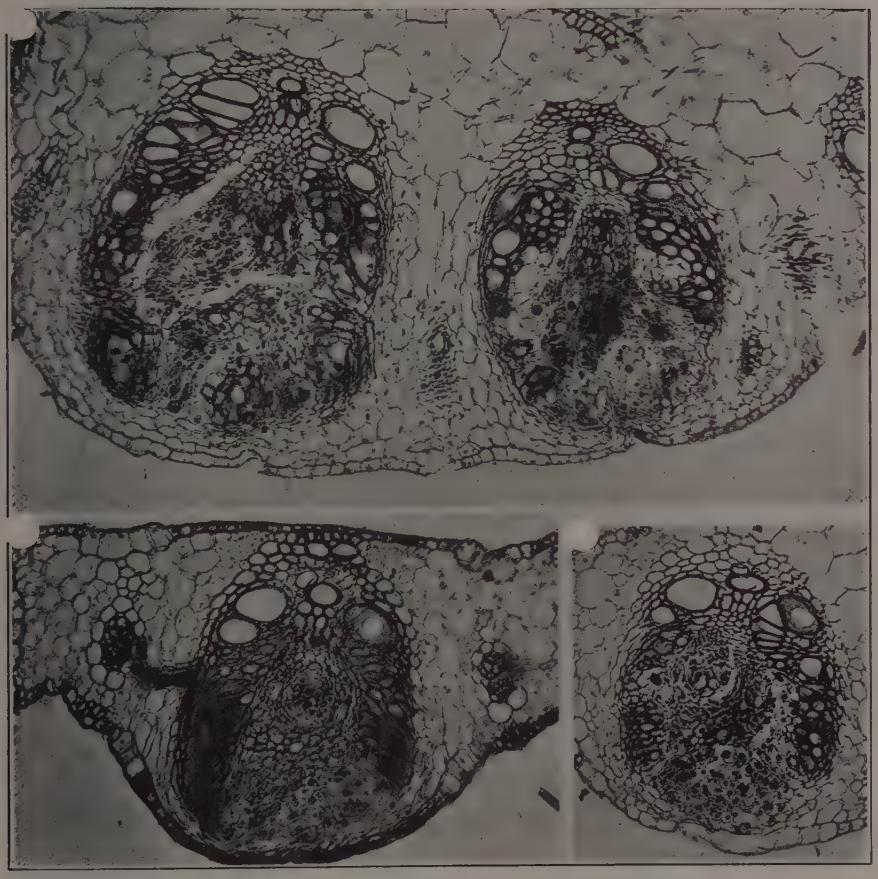


Fig. 11. Fiji disease. All figures x 100. *Upper.* A cross section through a portion of a diseased leaf sheath showing two affected vascular bundles. *Lower left.* A cross section through a leaf gall showing cell proliferation of the phloem. *Lower right.* A cross section through a portion of a diseased leaf sheath showing the disorganization and cell proliferation of the vascular bundle. After Kunkel.

Of primary importance to the local industry was the establishment in 1946 of the Fiji disease project in American Samoa. Since Fiji disease occurs in Samoa and since environmental conditions there are highly conducive to the development and spread of the disease, newly propagated canes of commercial promise in Hawaii will be sent to Samoa in order to determine their relative degree of resistance to the disease. Information regarding the tolerance of local varieties to a foreign disease is essential in carrying out a satisfactory field control should Fiji or any other foreign disease gain entrance into Hawaii. At present nine commercial and promising Hawaiian varieties are being tested at our Vailoatai Substation in Samoa, a progress report on this project is discussed in another article entitled, "The Fiji Disease Project In Samoa." Without exception Fiji disease has caused greater monetary losses than any other sugar cane disease.

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Observations On The Sugar Industry In Fiji — 1947

By J. P. Martin

A brief review of the sugar cane culture in Fiji is presented. The major cane diseases occurring in Fiji, the effect they have had on sugar production, the commercial varieties and their relative resistance to disease, and the methods now employed for controlling the various diseases are also discussed.

The Fiji Islands, some 250 in number, vary greatly in size and climatic conditions. The two larger islands Viti Levu, 4,053 square miles, and Vanua Levu, 2,128 square miles, are in large part of volcanic structure and are very mountainous. The sugar-cane industry is confined to these two islands, chiefly along the coastal belts and to some extent to the narrow valleys extending inland along the large streams and rivers. The first sugar factory was established in 1870 near Suva and soon after other factories were started.

The sugar production in the Fiji Islands is controlled by the Colonial Sugar Refining Company, Ltd. (established 1856), with its head office in Sydney, Australia. This organization also operates a number of sugar estates in New South Wales and Queensland, Australia, and is known throughout the Pacific as the C. S. R. Company. On the island of Viti Levu there are four sugar estates, namely, Nausori, on the Rewa River; Penang on the north coast; Rarawai in the valley of the Ba River; and Lautoka on the northwest coast (Fig. 1). On Vanua Levu is located another sugar estate at Labasa (Lambasa). The sugar-producing areas lie between latitudes of 16.25 and 18.25 degrees south of the equator. At present some 95,000 acres of land are devoted to sugar-cane culture on the five estates with an annual production of 130,000 - 140,000 tons of sugar. Inasmuch as the rainfall is not uniformally distributed throughout the year, the cane on the west and northwest sides of Vitu Levu frequently suffers from drought during the dry seasons.

Sugar cane is normally planted from November to May and is harvested at the age of 15 to 18 months from June to December of each year. No irrigation is practiced on any of the sugar estates. The Mauritius bean, *Stizolobium aterrimum,* and several varieties of cowpeas, *Vigna catjang,* and pigeon peas, *Cajanus indicus,* are grown and plowed under as green manure for supplying nitrogen to the soil just prior to planting sugar cane; with this practice very little nitrogen in the form of commercial fertilizers is applied to the plant crop. However, ammonium sulphate at the rate of 100 to 300 pounds per acre is applied to the ratoon crop. In the past the general practice has been to grow one plant and one ratoon crop, Fiji disease rendering additional ratoon crops unprofitable.

In farming the cane lands (Figs. 2, 3, 4, and 5) the plan is to have 25 per cent of the acreage in plant cane, 25 per cent in ratoons, 25 per cent in young cane, and 25 per cent in fallow. Due to economic, environmental, and disease factors it is not always possible to adhere to this scheme of field culture. The yield in tons of cane per acre from plant cane averages from 22 to 24 and from ratoon cane 15 to 18, with a POCS (Pure Obtainable Cane Sugar) average of from 13 to 14. The POCS is the reciprocal of cane ratio or quality ratio which are the terms commonly used in Hawaii. At times the POCS runs as high as 16.5 which is equivalent to a cane ratio of 6.

Fig. 1. The factory and some of the cane fields at Lautoka Mill Company, Ltd., as seen from the air.

Fig. 2. A general view of cane fields at Lautoka sugar estate as viewed from the Drasa Training Farm.

Except at Nausori, all cane is transported from the fields to the factory by rail. At Nausori a portion of the cane is loaded on punts or barges and transported to the factory which is located on the bank of the Rewa River. The railroad is a two-foot gauge, 35-pound rail, and on each estate branch lines lead from the center of the cane-growing areas to the main line. Portable tracks are used for hauling the cane from the fields (Fig. 6) to either the branch lines or to the main line. It is interesting to note that on the Lautoka estate the main line runs from Kavanagasau through Lautoka to Nabuna a distance of approximately 130 miles. This line is maintained by the C.S.R. Company and, in an agreement with the Government that has been in effect for many years, a bi-weekly train schedule is provided for the people without charge. This is stated to be the only free passenger train in the world (Figs. 7 and 8) and because of this most uncommon proceeding it was featured by Ripley in his "Believe it or Not" column.

At present there are eight commercial cane varieties grown in Fiji; the percentage of each variety and the average rainfall over a period of 40 years or more at each estate follow:

	Cane Varieties							Rainfall
Sugar Estate	Badila	POJ 2878	Pompey	H 109	Ajax	Argus	Malabar	Galba	In Inches
Nausori	25					45	20	10	116
Penang	65	10	20		3			2	79
Rarawai	25		50		15			10	82
Lautoka	55	1	25		15			4	69
Labasa	20	15		55	10				83

The development and testing of new cane seedlings in Fiji have been conducted at Rarawai and are at present under the direction of J. Trivett, Cane Breeder and Field Chemist.

The variety Pompey (7R428) was propagated in 1907 at Rarawai. It is a light-green, waxy, large-stalk cane and has proved to be very resistant to both Fiji disease and downy mildew.

Ajax (22R226) is a Badila x H 109 seedling and was propagated in 1922. It is a waxy, bluish-purple, large-stalk cane. Due to its susceptibility to Fiji and downy mildew diseases it has been somewhat limited in its spread in certain localities where these diseases have been serious factors in cane culture.

Argus (18R1167) is an H 109 seedling and was propagated in 1918. It is a reddish-yellow large-stalk cane and is resistant to Fiji disease. This variety has been most popular under conditions at Nausori.

Malabar (Yellow Caledonia) was grown rather extensively in the past, but in more recent years has been replaced by higher sugar-yielding varieties. Malabar is somewhat susceptible to Fiji disease and for this reason its spread has been restricted in some localities.

Galba (25R408), a Badila seedling propagated in 1925, is a light-colored, large-stalk cane and is proving to be a very promising variety. The fact that it is resistant to Fiji disease makes it very desirable in those areas where this disease has greatly reduced sugar yields.

The sugar estates own and operate only a very small amount of the sugar-cane land. A large portion of the cane is grown by Indian farmers or tenant farmers who lease the land from the C.S.R. Company. Each farmer has from 10 to 12 acres of cane land. Then again a large acreage of cane is grown by independent

Fig. 3. Fields of Badila cane of different ages at the Lautoka estate.

Fig. 4. Looking toward Lautoka from the Drasa Training Farm. Much of the cane land is comparatively level.

growers or contractors who either own the land or rent the land from someone other than the C.S.R. estates; these areas vary in size up to 100 acres. The operators of these lands are mostly Indians but there are some Fijians in the group. There are also a few European growers who either operate their lands directly or lease them to other growers. In all cases the cane is harvested by its respective owner, and is transported to the factory by rail and milled by the estate (Figs. 9, 10, 11, and 12). The cane from each field is weighed at the factory and the final settlement on the basis of sugar yields is made by dividing the cane yields by the average quality ratio at the factory of all canes harvested during the grinding season.

Drasa Training Farm

At Lautoka the writer visited the Drasa Training Farm (Figs. 13 and 14) with Mr. Potts, Head Overseer and Mr. Wayne, Chief Chemist. This farm is under the direct supervision of the Lautoka sugar estate, and the object is to train Fijian youths so that they will be able to start and carry on with their own sugar-cane farms. The boys are about 17 years of age when they enter training and are selected from different districts of the island; about 25 are selected each year for the 3-year course. In addition to their training in sugar-cane culture, which includes all field operations such as plowing, planting, cultivating, weeding, and harvesting, the youths are taught how to grow their own food crops. During the training period the boys receive a certain sum of money for expenses and are credited with a definite amount. At the end of the training period they have acquired sufficient knowledge and funds to start and manage their own farms. It was pointed out that this training plan has been in effect for a number of years and that the results have been highly satisfactory.

Cane Diseases

While en route to American Samoa C. A. Wismer and the writer were afforded the opportunity (January 2, 1947) to visit Nausori which is located on the Rewa river some 15 miles from Suva. The sugar industry in general, but with special emphasis on cane diseases, was discussed with H. King-Irving, Manager at Nausori and General Manager of the other four estates. The fields at Nausori were visited with W. F. Stephenson, Field Superintendent, and it was possible to study Fiji disease (Figs. 15, 16) and downy mildew under field conditions. At the time of this visit Fiji disease was considered of minor importance; however, downy mildew was causing some damage and the incidence of the disease was on the increase. The main reason for its spread was the planting of corn between the cane rows or in close proximity to cane fields. Corn, more commonly referred to as maize in Fiji, is also attacked by downy mildew and acts as a host or a carrier of the disease.

Upon returning from Samoa the writer visited Lautoka and Rarawai sugar estates in Fiji. Through the courtesy of E. H. Griffiths, Manager, Lautoka Mill Co., Ltd., arrangements were made whereby in January 1947 the writer spent several days at Lautoka with J. L. Chalmers, Field Chemist. As the result of Mr. Chalmers' many years of field experience in Fiji, valuable information relative to the field control of Fiji and downy mildew diseases was secured as well as information regarding the sugar industry in general. The writer met several district and division overseers and enjoyed discussing their various field problems with them.

Fig. 5. Young ratoons of Badila cane at Nandi, a division of Lautoka. Forty years ago Fiji disease in this section caused very severe losses, but today it is of minor importance.

Fig. 6. A field of Badila, plant cane, at Lautoka.

One day was spent at Rarawai Mill Co., Ltd., with A. R. Rourke, Manager, W. Fenner, Field Superintendent, and Mr. Chalmers. Field conditions at Rarawai were in many respects similar to those at Lautoka. During this visit it was possible to study both Fiji disease and downy mildew in various stages of development. In discussing the cane diseases studied each disease will be treated separately.

Fiji Disease:

Fiji disease has been the greatest limiting factor in sugar production in Fiji with which the personnel of the estates have had to deal (Fig. 17). Since 1907

Fig. 7. The free passenger train arriving at 7:15 A.M. in Lautoka.

when the seriousness of the disease was first realized very definite field-control measures have been practiced, otherwise monetary losses from the disease would have been too great for the survival of the industry. A short discussion of field-control measures follows:

When new fields are to be planted the fields from which the cuttings or "seed cane" are to be obtained are carefully inspected for Fiji disease. If too many cases of the disease are found in a given field, and it is felt that the cutters will not be able to select a sufficient quantity of healthy planting material, another field is selected. It is of the utmost importance that all planting material be taken from disease-free plants. The cutters are trained to recognize the symptoms of Fiji disease and the supervisor in charge of the cutters is also specially trained to spot the disease.

Fig. 8. The free passenger train going through cane fields in the district of Nandi, Fiji.

Fig. 9. A portion of the mill yard at Lautoka.

Fig. 10. The storage yard at the Lautoka factory.

Shortly after the cane in plant fields has germinated the fields are inspected periodically and all diseased stools are rogued (Fig. 18) and burned. The roguing continues until the cane has closed in and every attempt is made to have each field rogued from 4 to 5 times. In isolated areas or where the fields are small, one man is assigned to approximately 100 acres and it is his duty to remove and destroy all diseased stools. However, in large areas it is advisable to rogue the fields by using

Fig. 11. Most of the cane is transported from the fields to the factory in railroad cars.

Fig. 12. The last of the "crush."

a number of men or a gang under a supervisor; with such a procedure each man inspects and rogues one line of cane at a time. The number of diseased stools rogued in each field is recorded and such records are used to determine the rate of spread of the disease and if the cane in any particular field can be used at a future date as a source of planting material. Roguing is also practiced in the ratoons. There are always many more cases of the disease in the ratoons than in the plant cane and Fiji disease has in the past prevented the estates from growing more than one ratoon crop.

As shown in the following table, which gives the relative degree of resistance of

Fig. 13. The mess hall at the Drasa Training Farm, Lautoka.

Fig. 14. The type of houses used by the Fijian youths while attending the Drasa Training Farm.

the eight commercial varieties now grown in Fiji to Fiji disease, some varieties are very resistant while others are very susceptible. In the case of the latter certain varieties produce excellent sugar yields but they cannot be grown in specific localities where conditions are highly conducive to the development and rapid spread of the disease. Close supervision must be maintained at all times by the estates in order that the many small growers may be properly advised as to what

Fig. 15. Showing Galba cane affected with Fiji disease at Nausori sugar estate. C. A. Wismer is holding the diseased plants.

varieties are best suited for a given district. At times it becomes necessary to plow out badly diseased areas and plant a more resistant variety.

In the more fertile lands, especially along the rivers, the disease is always much more severe than on the less fertile lands where the cane makes a slower growth. During 1934 Badila growing in some of the rich river lands became so badly diseased that it was necessary to plow out entire fields. Badila is listed as very resistant; however, under the most favorable conditions for the disease Badila can be seriously affected.

Badila has been grown in Fiji for the past 30 years or more as one of the leading commercial varieties. By planting healthy cuttings and by carrying out a systematic roguing program Badila has been successfully grown in the Nandi district where D. S. North first studied the disease (1910); at that time the disease was so severe that large cane areas were a total failure, and it was not uncommon to see crop losses of from 50 to 100 per cent. Mr. Chalmers pointed out this particular area in Nandi where Badila cane is now grown with very little loss from Fiji disease (Fig. 5).

Fig. 16. The variety Galba affected with Fiji disease. Note shortening of leaves and stunting of stalk growth in lower left corner.

Fig. 17. Young ratoons of Badila, in the foreground, affected with Fiji disease at Rarawai. Healthy cane on each side of J. L. Chalmers.

SHOWING THE RELATIVE DEGREE OF RESISTANCE OF THE VARIETIES NOW GROWN IN FIJI TO FIJI, DOWNY MILDEW AND LEAF SCALD DISEASES

Variety	Fiji	Downy Mildew	Leaf Scald
Badila	+	+	+
POJ 2878	=	—	—+
Pompey	+	=+	=
H 109	—	=+	+
Argus	=+	=	+
Malabar	=	=+	+
Galba	=+	=	+
Ajax	=	=—	+

KEY FOR SYMBOLS

++ Very highly resistant
+ Very resistant
=+ Resistant
= Somewhat susceptible
=— Susceptible
— Very susceptible
—— Very highly susceptible

Fig. 18. Cane fields are inspected and rogued at intervals and the diseased plants are burned. The boy in the picture has come to the edge of the field, first ratoons of Badila, after having inspected one row of cane.

During 1929 at Rarawai and 1930 at Lautoka the degree of infection of Fiji disease in the variety H 109 reached 90 per cent. In making field counts to determine the incidence of the disease only the healthy stools were counted. Ordinarily

the degree of infection in a field is made by counting the number of diseased stools. H 109 at these two estates proved to be an excellent sugar-producing cane but due to its very high susceptibility to Fiji disease it had to be replaced by resistant varieties. When H 109 was first planted only a few cases of Fiji disease were found on it but in a very short time the disease became a serious factor in the plant cane and a limiting growth factor in the ratoons. The variety proved so susceptible that all attempts to control the disease by roguing failed.

At Lambasa on Vanua Levu, where Fiji disease has never been a serious factor, H 109 has given excellent sugar yields. Today it occupies 55 per cent of the area devoted to cane at Lambasa while on the other estates on Viti Levu it could not be commercially grown because of its high degree of susceptibility to Fiji disease.

Fig. 19. Ajax variety affected with downy mildew at Lautoka. Definite leaf stripes are associated with this stage of the disease which is most severe during the warm, wet summer months.

Downy Mildew:

During the period from 1936 to 1938 downy mildew became very serious on POJ 2878 on the Rarawai and Lautoka sugar estates. In many cases 20 per cent of the cane was affected and it was not uncommon to find certain fields where 90 per cent of the cane was affected. It became necessary to eliminate POJ 2878 in many localities and plant varieties which were resistant. The sugar yields from POJ 2878 were highly satisfactory but its susceptibility to the disease prevented the culture of the variety.

At Nausori estate downy mildew was noted on the variety Argus, which is listed as somewhat susceptible. It was pointed out to us where some planters

grow corn in close proximity to cane and even where corn is planted between the cane rows. Downy mildew also attacks corn and for this reason it acts as an alternate host for the disease. At Lautoka the variety Ajax was found to be affected with downy mildew and the disease was also found on corn plants not more than 25 feet from the affected cane. The planting of corn near or in a cane field causes the disease to spread very rapidly; such a practice is not approved by the personnel of the sugar estates and every effort is being made to discourage the small farmer from so doing. The tolerance of the eight commercial varieties now grown in Fiji to downy mildew is given in the table under the discussion of Fiji disease.

Fig. 20. Downy mildew attacking Ajax at Lautoka. The tips of many of the leaves have become shredded which is a symptom of the disease during the winter months.

The first symptoms of the disease are the appearance of yellowish-white stripes running parallel to the vascular bundles on the very young leaves (Fig. 19). As the leaf matures the streaks become yellow, then a mottled reddish-brown and in a few cases a dark red color. The stripes are about one-eighth to one-half of an inch wide and often extend the full length of the leaf. As the result of the striping downy mildew is frequently called leaf-stripe disease. On the lower surface of the yellowish streaks a white, fluffy, "downy mildew," may be found which is composed of mycelium and spores of the causal fungus, *Sclerospora sacchari* Miy. The tissue in the stripes is weakened and the leaves often become torn or split along these lines, and for this reason the trouble is sometimes referred to as leaf-splitting disease. These symptoms are most common in the warm, wet summer

months and are associated with the conidial stage of the fungus. Affected plants in a field are readily spotted since they are usually very chlorotic.

On affected plants in the winter months there is often a rapid elongation of certain stalks as though they were going to tassel; these stalks stand out like flags some two to four feet above the surrounding canes. Such cases are known as

Fig. 21. Corn is also attacked by downy mildew and the planting of it near or in cane fields is discouraged since it aids greatly in the spread of the disease.

"jump-ups" and the stem tissue is soft while the leaves wither and become shredded (Fig. 20) and badly twisted. The "jump-ups" and shredded leaves are associated with the resting spore or oospore stage of the fungus. The disease is transmitted by spores which are borne by the wind.

Downy mildew over a period of years has been responsible for severe losses to the cane growers in Fiji and is regarded as second to Fiji disease in causing economic losses. Ever since it was first recognized in Fiji, definite control measures have been employed; the measures are in many respects similar to those used for controlling Fiji disease, and may be summarized as follows:

The very susceptible varieties are not planted in areas where the disease is known to occur year after year. When a field is severely affected it is burned prior to harvesting — burning mature cane is not practiced in Fiji. All fields are periodically inspected and the diseased plants are rogued and burned. As mentioned before, the planting of corn (Fig. 21) near or in cane fields is discouraged.

Chlorotic Streak Disease:

This disease occurs in Fiji, especially in the low-lying and poorly drained areas.

It has caused some losses but to date it has not reached the seriousness of Fiji and downy mildew diseases.

At Rarawai chlorotic streak was observed on the variety Trojan which is proving to be a very promising variety as a commercial cane. The disease was also noted on Argus at Nausori and was causing considerable damage in a localized area. Every attempt is made to select only healthy planting material and by carrying out such a practice the incidence of the disease has been held to a minimum. The advisability of roguing diseased plants as soon as they are observed is being studied, especially in seedling areas. Records are maintained regarding the susceptibility of all canes to the disease.

Fig. 22. Young ratoons of Argus variety growing in a wet and poorly drained area at Nausori. Definite leaf symptoms of potassium deficiency were noted in this field.

Eye Spot:

A small amount of eye spot was pointed out at Nausori but the disease at this time was by no means serious; it has at times caused serious losses on a few varieties.

Miscellaneous Diseases:

Several cases of pokkah boeng were found, but in no instance was it of major importance. Leaf freckle and leaf buckle were seen on a few varieties but here again they were of little economic importance. Ring spot, which now occurs in almost every country where sugar cane is grown, appeared on the older leaves of several varieties but was of little significance.

Leaf scald and gumming diseases occur in Fiji but during the writer's visit not a single case of either disease was found. At one time gumming disease was of major importance but its control has been effected by roguing diseased plants and planting resistant varieties.

Potash deficiency, as manifested by a retardation of growth and a premature yellowing and drying of the older leaves, was very much in evidence in fields where drainage was a factor (Fig. 22). These symptoms were very definite and it was suggested to Mr. Chalmers that an application of potassium be applied to the soil in experimental areas.

A few plants showed the early symptoms of iron deficiency but Mr. Chalmers pointed out that this condition has never been a limiting factor for normal growth.

The writer is greatly indebted to Messrs. King-Irving, Griffiths and Chalmers of the C.S.R. Company for arranging the field trips on the various sugar estates and for supplying the information presented in this article.

Sugar Prices

96° CENTRIFUGALS FOR THE PERIOD
DECEMBER 16, 1946, TO MARCH 15, 1947

Date	Per pound	Per ton
December 16, 1946—January 17, 1947	5.94 ¢	$118.80
January 18, 1947 — March 15, 1947	6.125¢	122.50

THE HAWAIIAN PLANTERS' RECORD

EXPERIMENT STATION STAFF

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